

## 印度北部 Pali Gad 流域资源利用模式研究

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**摘要:** 喜马拉雅西部独特的、丰富的自然资源对当地居民生计及生态服务等方面起着重要的作用。由于长期以来当地居民与山地生态系统的相互作用, 特别是农业生产、畜牧业放牧、薪柴采集以及其他多种多样的资源利用方式, 形成了一种特殊的山区文化景观。本文以印度北部的山地小流域 Pali Gad (共有 25 个村子) 为例, 主要研究当地的资源利用状况, 利用卫星遥感数据对该地区可利用自然资源进行评估分析, 通过从户到户的社会经济调查, 对其提供的生态服务功能以及受威胁的程度进行估计, 研究分析了村民对资源需求及获取的时空变化情况。结果显示, 平均每人每天的薪柴采集量为 1.12 kg, 平均每人每天通过修剪枝叶获得饲料采集量为 3.69 kg, 平均每人每天从森林中采集草料的量为 3.25 kg。对生态系统服务功能进行估测的结果显示, 森林可提供更多的临时调节功能, 而农业更多的是支撑服务功能, 河流 水体给当地人提供了文化服务功能。以山区典型的人 - 地生态系统为例, 这类生态系统中的自然资源破碎化程度很高。研究发现, 该区域贫瘠土地上的自然资源需求还在不断增加。因此, 从长远来看, 人对资源的无止境获取将不利于整个流域的可持续发展。

**关键词:** 生态系统服务; 喜马拉雅西部; Pali Gad 流域; 资源利用和需求

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## Resource Utilization Pattern Analysis in Pali Gad Watershed of Tehri, Garhwal Himalaya (India)

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**Abstract:** The western Himalaya has had a central role as a life support system for the local people and as a source of ecological services . This long term use of these resources , including livestock grazing, fuel wood collection and a variety of other uses , has shaped its montane cultural landscape . The present paper focuses on resource utilization in the Pali Gad watershed, which consists of 25 villages situated in the lesser Himalaya . Using a satellite derived map, natural resources available in this area were assessed, and the ecosystem services provided by them and level of pressure on them were computed through a door to door socioeconomic survey . The study revealed a spatio-temporal variation in the resource demand and extraction at the permanent villages . Average fuel wood consumption was 1.12 kg day capita, fodder consumption was 3.69 kg day capita from lopping and 3.25 kg day capita from grass collection from forest . An attempt has been taken to

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evaluate the ecosystem services . The forest provides more provisional and regulatory services, whereas agriculture provides more supporting services and river bed water bodies serve more cultural purposes for the locals . This study contributes an example of a human shaped ecosystem in a mountainous region where an additional fragmentation of natural resources exists . An increase in resource demand has been noticed in the less productive lands of the region . This has resulted in increased resource extraction from the entire watershed may not be sustainable in the long run .

**Key words:** Ecosystem services ; Himalaya; Pali Gad; Resource utilization and demand

Recent approaches to development in India, especially in the Himalayan region, focus on micro level planning and execution of resource conservation programs (Sundaram, 1980) . The forest resources in these areas are dominated by *Quercus* spp . (Oak), which is highly associated with the life support system for the local inhabitants (Singh and Singh, 1992) . Escalation of biotic pressure on natural resources has made the fragile Himalayan ecosystem vulnerable to a variety of ecological maladies (Sharma *et al.*, 1999) . The degradation of the region as a result of road construction, market forces, overpopulation, and other forces has changed the traditional sustainable use of these resources (Awasthi *et al.*, 2003) . Moreover, the transformation of nomadic pastoralism to nuclear transhumance (migration by only one or two people per family) (Farooquee, 1992) has increased the resource extraction process (Singh and Singh, 1991) . Landholdings are small and fragmented, consisting mostly of marginal uplands . In this type of mountain subsistence agriculture system, the demands on the forest are numerous and fairly self-evident . The consumption pattern in the region is firmly correlated to its natural resource base in area and invariably most of the energy demands are met by the forest s resources (Vasudevan and Santosh, 1987; Samant and Dhar, 1997) . Furthermore, the influx of tourism has increased the pressure on the surrounding resources (Singh, 1983) . This scenario where almost 90 per cent of energy demand is met with natural resources calls for careful resource planning (Sharma *et al.*, 1999) .

Pali Gad Watershed in the Western lesser Himalayas is a similar kind of watershed, which drains into the river Yamuna . The watershed provides vast biological resources for humans and their livestock . The mountainous area endowed by the environmental and topographical conditions offers limited areas for agricultural activities in the narrow fissures of the lowland valleys . The

long term use of the mountains has resulted in a montane cultural landscape where the present pattern of resource utilization and habitats and their content of configuration reflect human impacts at different levels . The exploitation of biological resources from remote areas by either moving most livestock from permanent settlements or by collection of fuel wood and fodder has made it necessary to assess the critical areas affecting resources . The present study was conducted to assess the resource utilization patterns, ecological importance of the Himalayan landscape forests, and its conservation needs .

## Study Area

Pali Gad watershed constitutes an important watershed of the Agalr basin in the outer Garhwal Himalayan range and forms a part of the Tehri Garhwal and Dehradun districts . It lies between 30.29 ° N to 30.35 ° N and 78.07 ° E to 78.13 ° E . The average altitude varies from 1 160 m to 3 020 m a.s.l . The watershed covers an area about 60 km<sup>2</sup> (approx) . The area is bounded by the main Mussoorie ridge (outermost ridge of the Himalayas) in the south, the Nag Tibba ridge of the outer Himalayan range in the north, the western part of Surkanda Temple in the east and the confluence of Aclar and the Yammuna River in the west . This region is mostly covered by forest of oak, pine and deodar or deodar mixed . The patches of highland grasslands are found at a higher altitude . Shrubs and grasses mostly cover the lower slopes . The outer aspect of lower slopes (mostly southern aspect) is covered by Xerophytic vegetation . The location and setup of the study area is shown in Fig.1 .

## Materials and Methods

For the present study, a land use land cover map derived from IRS-1D LISS III + PAN (merged data-5 m spatial resolution) prepared at 1:50 000 was taken . The geospatial information about the distribution of the villages, road network and topography

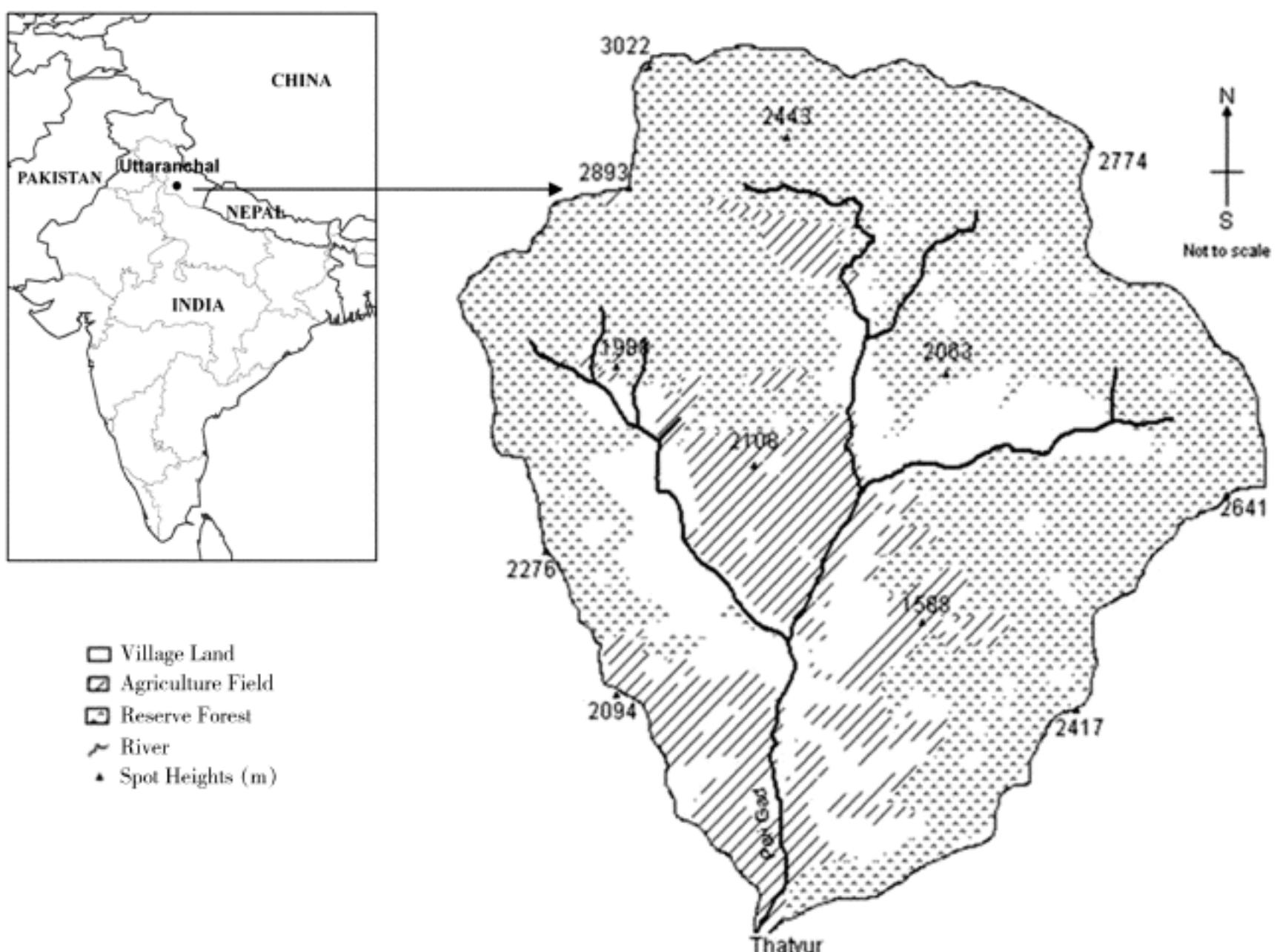


Fig. 1 Location of study area

was taken from the topographic sheets published by Survey of India (SOI). The resource distribution and availability was assessed using these maps. An extensive field work of fifteen days was carried out to understand the relative authenticity of the prepared spatial maps.

For the socio-economic study, a structured questionnaire (Patton, 1981; Clarke, 1986) was used to interview the members of each household. A door to door survey was conducted in the 17 villages ( $n = 105$  households) of the study area to collect information on socio-economic status, land use and resource use pattern. The village names are varying as per the slight topographic features and or the origin. The total villages as per the record are 25, but due to proximity to each other only 17 are taken into account. During the survey, school going children and state government workers were also approached to document the change in land use patterns of the region.

## Results

### Resource Distribution

The distribution of the resources has been as-

sessed using the land use land cover map derived using IRS-1C LISS + PAN data (Joshi *et al.*, 2003). Forest is a dominant resource covering 62.7% of the total area in Pali Gad watershed, followed by shrubs 23%, agriculture 7.8%, tree farmland cover 5.5% and river bed 0.6% of geographical area. The forest cover per capita is around 0.65 ha which is approximately equal to the record of Dehradun district (capital of Uttarakhand). It reveals that the watershed is deficient in the forest resource in spite of forest cover. The canopy density of the preferred woody species (for fuel wood and fodder) is lowest (ca. 20% - 30%) near villages located at lower altitudes and highest (ca. 60% - 70%) at middle elevations. However, the higher ridges also have low density due to nomadic pastoralism and camp sites. The density is also biased of the usefulness of the tree type. The oak forests are lopped (irrespective of the elevation and distance from villages) because of their multipurpose uses.

## Resource Utilization Pattern

There are 1082 families in the study area of which 70% are migratory. A general profile of the area prepared on the basis of information collected from the different government departments is given in Table 1. The profile of the villages on an average family basis is given in Table 2. It is basically prepared after the door to door survey. The database reveals that there is a population of 1082 people primarily dependent on the resources of Pali Gad Watershed. The primary occupation of the inhabitants is farming (85%). From April-November, paddy is grown in irrigated agricultural fields and vegetables viz., potato and beans in the rain fed agricultural fields. The area of land devoted to agricultural has been found to be increased in the subsequent survey carried out by Survey of India (SOI) in 1963 and 1986. The land transformation from forest to agricultural lands has occurred in the majority of the areas and in lower altitudes from scrub to agriculture has also

been found (Li, 2005). The map generated using satellite remote sensing data also reveals an increase in agricultural areas (Joshi *et al.*, 2003). The socioeconomic survey showed that until the last decade (late 1990s), most of the villagers were growing cereals and millets. After the availability of the seeds in the local market, the people have switched cultivation over to cash crops viz., potato, peas and beans. However, some of the villages at high altitude still cultivate millet and cereals but at a much lower amount. The lands in these regions are not productive enough to sustain agriculture for economic benefit. This has resulted in additional pressure on the adjoining forest areas. The life in the hills is labor intensive, specifically for women. The low fertility of the land and low availability of resources have resulted in greater dependency on natural resources and hard work. A rough sketch of monthly activities carried out by the local people as per the socioeconomic survey is given in Table 3.

Table 1 Socio-economic structure of villages

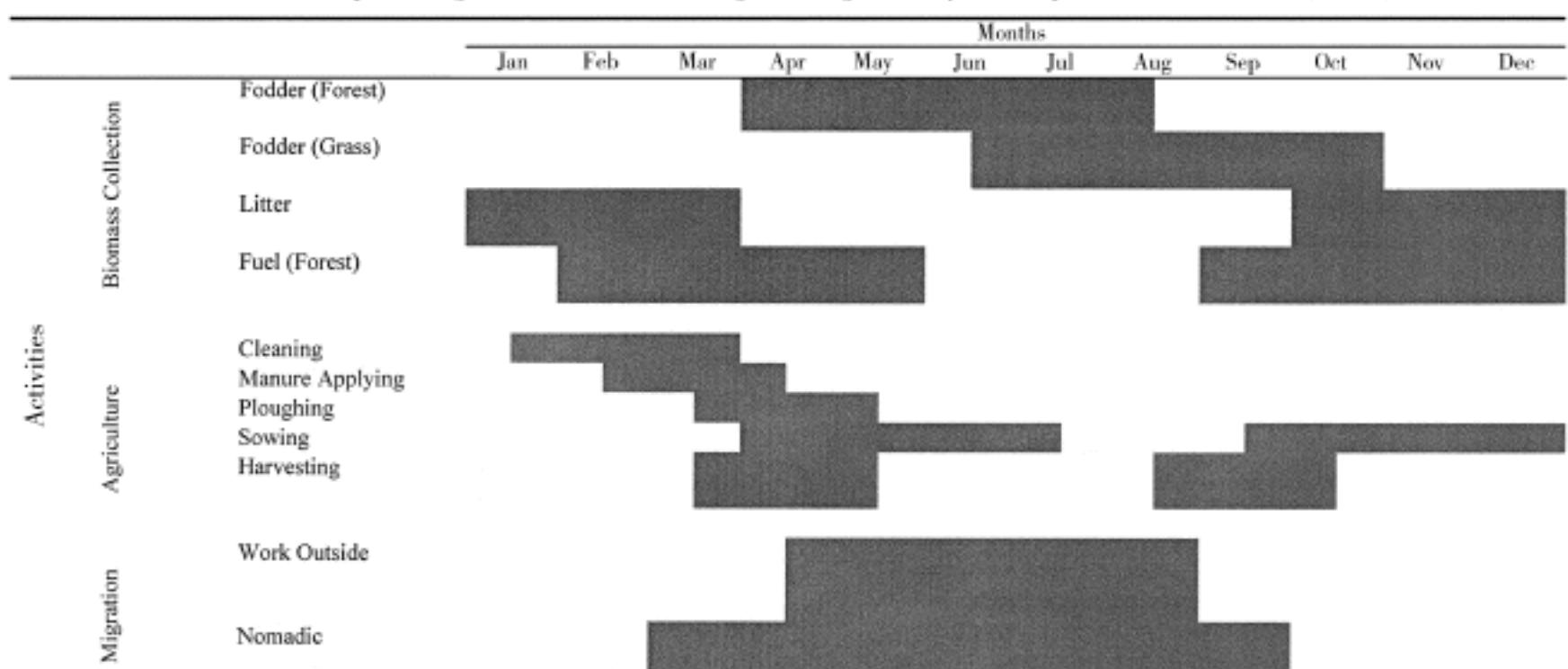
Village names	Human		Land				Cattle							Infrastructure						
	HH	Pp	Ag (Ni)	Ag (i)	Ag (Tt)	Ar (Tt)	C	O	B	S	G	H	M	Tt	Sc	PS	PO	El	Rd	Tel
Airi	29	156	26.00	2.58	28.57	178.29	15	8	13	0	8	1	8	53	1	0	0	0	0	0
Bangsil	49	214	60.16	1.73	61.89	115.58	35	40	31	15	45	1	4	171	3	0	1	0	1	0
Bhuyansari	51	279	39.78	1.71	41.50	91.78	82	44	60	21	90	2	12	311	1	0	0	0	0	0
Burkot	18	106	15.20	0.47	15.67	27.96	18	15	15	4	8	1	2	63	0	0	0	0	0	0
Chak Pot	4	25	7.72	0.00	7.72	40.46	8	6	7	3	9	0	2	35	0	0	0	0	0	0
Dugada	59	300	NA	NA	44.31	109.35	NA	NA	NA	NA	NA	NA	NA	151	1	0	0	0	0	0
Kakaru	16	71	13.29	0.00	13.29	37.42	7	8	3	0	6	0	0	24	1	0	0	0	0	0
Khera Malla	27	165	27.03	0.00	27.03	123.64	28	32	32	10	14	2	8	126	1	0	0	1	0	1
Khera Talla	18	127	17.01	3.37	20.38	64.23	24	28	23	12	12	2	6	107						
Kinsu	34	171	19.03	5.78	24.81	78.35	40	34	36	7	20	1	3	141	1	0	0	1	0	0
Kuwa	27	186	10.11	4.89	15.00	67.69	25	10	10	5	10	1	4	65	1	0	0	0	0	0
Muldhar	67	387	69.70	1.70	71.41	128.35	36	40	44	11	31	2	10	174	1	0	0	0	0	1
Mundni	43	233	45.07	5.83	50.90	371.14	20	20	14	4	6	1	6	71	0	0	0	0	0	0
Munglori	49	319	42.83	4.65	47.48	177.21	40	50	41	20	60	2	20	233	1	0	0	0	0	0
New Digon	11	64	7.91	0.00	7.91	33.08	15	10	8	2	10	1	4	50	0	0	0	0	0	0
Old Digon	21	118	24.51	0.48	24.99	122.45	20	20	11	4	12	1	2	70	2	0	0	0	1	
Ontor	50	283	48.24	7.97	56.21	97.00	30	40	46	20	50	2	10	198	1	1	0	0	0	0
Papra Malla	42	218	34.58	5.63	40.21	122.36	34	40	36	20	32	2	10	174	1	0	0	1	0	1
Pujaldi	14	95	3.78	1.59	5.37	8.97	15	20	10	5	10	0	2	62	0	0	0	0	0	0
Siras	140	771	0.00	0.00	113.87	781.23	20	25	31	10	22	3	15	126	1	0	0	0	0	0
Sirwa	41	196	47.09	0.86	47.95	164.11	0	0	0	0	0	0	0	99	0	0	0	1	1	1
Tewa	60	338	33.73	6.48	40.21	148.82	25	30	35	10	40	1	15	156	0	0	0	0	0	0
Thatyur	105	360	3.78	2.02	5.80	22.91	20	10	17	5	10	0	0	62	2	1	1	1	1	0
Thika	100	521	25.97	3.68	29.65	239.76	42	32	28	8	19	1	4	134	1	0	0	1	0	0
Udarsu	7	50	6.01	1.56	7.57	52.06	10	10	8	2	10	0	3	43	0	0	0	0	0	0
Total	1082	5753			849.66	3404.20								2899						

NB: HH-Households, Pp-Population, Ag (Ni) -Agriculture (Non-Irrigated), Ag (I) -Agriculture (Irrigated), Ag (Tt) -Agriculture (Total), Ar (Tt) -Area (Total area of village) C-Cow, O-Ox, B-Buffalo, S-Sheep, G-Goat, H-Horse, M-Mule, Tt-Total, Sc-School, PS-Police Station, PO-Post Office, El-Electricity, Rd-Road, Tel-Telphone Nb: Area in Hectares

Table 2 Socio Economic Status as per survey

Name	Hh	Pp	Statistics per family (Average)						LPG	Kerosene	Electricity	
			M f	C(m)	C(nm)	Tt	F f (d)	F g (d)				
Airi	29	156	8	3	2	5	13(2)	15(2)	7.2(2)	A	P	A
Bangsil	49	214	2	1	2	3	8.75(3)	8.75(6)	1.33(6)	A	P	A
Bhuyansari	51	279	NA	NA	NA	NA	NA	NA	NA	A	A	A
Burkot	18	106	NA	NA	NA	NA	NA	NA	NA	A	A	A
Chak Pot	4	25	NA	NA	NA	NA	NA	NA	NA	A	A	A
Dugada	59	300	8	2	2	4	22.5(2)	8.6	3.2(NA)	A	A	A
Kakaru	16	71	NA	NA	NA	NA	NA	NA	NA	A	P	A
Khera Malla	27	165	7	6	2	8	32.5(1.5)	22.5(1.5)	11.6(1.5)	A	A	A
Khera Talla	18	127	5	5	2	7	12.5(3)	12.5(NA)	NA	A	P	A
Kinsu	34	171	7	3	2	5	25(6)	15(10)	5.5(6)	P	P	P
Kuwa	27	186	6	5	0	5	4(5)	30(1.5)	NA	A	P	A
Muldhar	67	387	10	2	3	5			37.5(0.5)	P	P	A
Mundni	43	233	12	10	2	12	22.5(6.5)	50(1.5)	16.25(2.3)	A	P	A
Munglori	49	319	11	28	3	31			35(1)	A	P	A
New Digon	11	64	12	5	2	7	37.5(2)	60(2)	8(2)	A	A	A
Old Digon	21	118	NA	NA	NA	NA	NA	NA	NA	A	P	A
Ontor	50	283	8	6	2	8	55(4)	27.5(NA)	10.7(3)	A	A	A
Papra	42	218	10	9	2	11	41.25(1.5)	33.75(1.5)	5.8(1.5)	A	P	A
Pujaldi	14	95	7	3	2	5	5(2)	AN	27.5(2)	A	P	A
Siras	140	771	6	3	2	5	20(3)	17.5(2)	5(2)	P	P	A
Sirwa	41	196	NA	NA	NA	NA	NA	NA	NA	A	P	A
Tewa	60	338	NA	NA	NA	NA	NA	NA	NA	A	A	A
Thatyur	105	360	8	1	2	3	27.5(2.5)	27.5(2.5)	14.5(1.5)	A	A	A
Thika	100	521	NA	NA	NA	NA	NA	NA	NA	A	P	A
Udarsu	7	50	7	3	0	3	45(3)	22(2)	17.5(2)	A	A	A

NB: HH-Households, Pp-Population, M f-Members per family, C(m)-Cattle (milking), C (nm)-Cattle (non-milking), Tt-Total, F f(d)-Fodder from forest (distance traveled to collect), F g(d)-Fodder from grass (distance traveled to collect), FW F(d)-Fuel wood from forest (distance traveled to collect), LPG-Liquefied Petroleum Gas, A-Absent, P-Present

Table 3 Chart representing various activities of villagers throughout the year (adapted from Awasthi *et al.*, 2003)

### Resource Demands

The demands of the locals from the forest are for fuel, fodder, and leaf litter and non-timber forest products. The resource demand for the different villages

varies as per the location of the village. The villages located in the altitude range of 1 000 - 1 800 m require relatively less biomass from natural resources for day to day activities unlike the villages located at the altitude

range of 1 800 - 3 600 m . There is a seasonal variation in the nature of resources extracted from the forest (Table 2 and Table 3) . The collection of firewood is done throughout the year, whereas lopping mostly occurs from mid January to early May . The leaf litter is collected during the winter season which is from October to March of next year .

In the watershed, the requirements have been estimated as 3.69 kg capita day fodder from lopping, 3.25 kg capita day fodder from grass from the forest and 1.12 kg capita day fuel wood from the forest . The total livestock in the region is 2899 including cows, oxen, buffalo, sheep, goats, horses and mules . Cows and buffalo are basically kept for their milk, whereas other animals are kept for their food value as well as for performing labor intensive work . The other benefits of raising livestock are their availability of dung for manure in the local fields . The increase in the livestock population has also increased the demands of lopped fodder and grazing grounds . The collection of resources also varies between permanent villages and temporary huts . The temporary huts in the high ridges consume highest amount of fuel wood throughout the year for temporary construction and as fire wood .

The development activities viz ., road construction clearing, dam repairing, etc . also affects the resource demand of the area . These activities predominantly occur during the dry seasons . After the creation of Uttarakhand as a state, these pressures increased tremendously . The increase in pressure is attributed to the extraction of wood timber for development activities . In addition to the fuel wood, the construction of lodges and temporary rest houses demands wood from the surrounding forest . The demand for the day to day activity bounds the locals to extract the resource . There is a spatial variation in the composition of the fuel and fodder species consumed . The preferred species are *Quercus* spp . for fuel and fodder demand, however in the high ridges, *Abies* are also consumed . Consumption in camping sites varies according to the tourist inflow in the areas . An estimate gathered from the socio-economic data reveals that 4 kg capita day fuel wood is required and the demand by these masses could in-

creases to 7 kg capita day in the winter season .

### Ecosystem services

Unlike other parts of Himalaya, the region is devoid of *soyam* civil forest (forest of villages blocks for management and resource utilization) and *van samiti* (forest department shares forest land with local people for management) . However, there is a high level of understanding of the importance of forests within the local people . The tree farmlands are managed for the protection of the environment and for use during harsh climatic conditions . During the survey, an attempt was made to record the importance of ecosystem resources and services to local people . Ecosystem services were categorized as provisional, regulatory, cultural and supportive . The sample size ( $n = 105$  household) was taken into consideration . The forest ecosystem provides the maximum ecosystem services and other ecosystems viz ., agriculture, grassland, river water body and tree farmland provide medium services, whereas scrub supports the least services (Table 4) . The forest provides more provisional and regulatory services while agriculture supports more supporting services and river beds water bodies provide more cultural services to the locals .

### Discussion

The pattern of resource utilization is a major cause of alteration in the composition and structure of vegetation . The expansion of agricultural fields due to demand for cash crops has degraded the forest condition (Joshi *et al.*, 2004; Joshi and Gairola, 2004) . Moreover, the increase in the cattle population has enhanced pressure on the grazing grounds as also the demands for lopped fodder from the forest . The change in agricultural practices from millets cereals to cash crops has already reduced the availability of agricultural by-products as fodder . The increasing human population has not only expanded the fuel wood and fodder demand but the extraction of them has also increased . Resource extraction has been found to be proportional to the number of female family members per household . Subsequently, the number of livestock is also affected . The studies carried out by Schmidt-Voigt (1990), in Nepal and Awasthi *et al.* (2003) in Uttarkashi (India)

Table 4 Ecosystem Services

	Agriculture	Forest	Grassland	Ecosystem types			Scrub	Tree	Farmland
				River	Water Body				
Provision									
Food	5	4	3	4		1.5		2.5	
Biochem and pharmaceutical	1	4	2.5	2		1		1.5	
Genetic resource	1	3	1.5	2		1		2	
Fuel wood	1.5	5	1	0		2		4	
Fiber	2.5	2	1.5	0		2.5		3.5	
Ornamental	1	1	1	1		1		1	
Fresh water	1	4	1.5	5		1		2.5	
Regulating									
Air quality	2.5	4.5	2.5	2.5		1.5		3.5	
Climate regulation	1.5	4.5	2	3.5		1		3.5	
Erosion control	2.5	4.5	2.5	1		1.5		4	
Ecosystem Services	Water purification	1	3	2	4	1		1.5	
	Waster treatment	2.5	2	1	2.5	2		1.5	
	Regulation to human disease	2.5	3	1.5	2.5	1.5		2.5	
	Biological control	4.5	3.5	3.5	1.5	2		3	
	Detoxification	1.5	3	3	1	1		2	
	Strom protection	2	2	2	1	1		1	
Cultural									
	Cultural diversity and identity	2.5	3.5	3.5	5	1		1	
	Recreation tourism	1	4	4.5	5	1		1	
Supporting									
	Primary production	3.5	1	1	1.5	1		1.5	
	O <sub>2</sub> production	2	4	2	1.5	1		2.5	
	Pollination	5	3.5	2.5	2	1.5		1.5	
	Soil formation & retention	3	2.5	2.5	1	1		2	
	Nutrient cycle	4.5	3	3.5	2.5	1.5		2.5	
	Wildlife habitat	1.5	4	3.5	4	1		2	

NB: Values ranging from 1 - 5; Purely based on socio-economic survey and knowledge base .

found higher demand than the present study . This is probably because the altitudes of these study areas are much higher than those measured in this study . At higher altitudes , fuel wood demand is found to be relatively higher than in low altitude areas , even during the summer . Dependency on the preferable forest resources has been reported by the other workers also . There are several studies of resource utilization that emphasize the general role of socio-economic and environmental factors (Baudry, 1993; VeldKamp and Fresco, 1996; De Koning *et al.*, 1998; Van der Veen and Otter, 2001; Hietel *et al.*, 2004) . The present study is able to evaluate the ecosystem services which are valued correctly by the people using them ( Wackernager and Rees, 1996) .

## Conclusion

The present study identifies the unsustainable trends of resource harvesting prevalent in Pali Gad Wa-

tershed . The transformation of lifestyles due to changing socio-economic conditions is the root cause for these trends . The direct evidences are the expansion of agricultural land, intensification of agriculture, and increase in livestock and human population . Considering the present trend, it can be inferred that within the next few decades the forests in the vicinity of the permanent villages and camp sites would be used up for day to day activity . The unavailability of preferred species near accessible areas will force people to relocate to other areas . The increase in tourist and development activity after the formation of the Uttarakhand state is degrading the high altitude forest . The result will be the lowering of the timberline and shrinking of forest resources in the region . The generation of a similar type of database for other watersheds in different altitudinal belts shall provide the footprints of unsustainable resource extraction and subsequent affects .

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## References:

- Awasthi A, Uniyal SK, Rawat GS *et al.*, 2003 . Forest resource availability and its use by the migratory villages of Uttarkashi, Garhwal Himalaya ( India ) [ J ] . *Forest Ecology and Management*, 174: 13—24
- Baudry J, 1993 . Landscape dynamics and farming systems: problems of relating patterns and predicting ecological changes [ A ] . In: Bunce RGH, Ryszkowski L, Paoletti MG eds ., *Landscape Ecology and Agroecosystems* [ M ] . Boca Raton: M . G . Lewis Publishers, FL
- Clarke R, 1986 . *The Handbook of Ecological Monitoring* [ M ] . Oxford: Gems UNEP, 298
- De Koning HGJ, Veldkamp A, Fresco LO, 1998 . Land use in Ecuador: a statistical analysis at different aggregation levels [ J ] . *Agriculture, Ecosystems and Environment*, 70: 231—247
- Farooquee NA, 1992 . Nuclear transhumance-a practice at the interphase sedentarism and transhumance [ A ] . In: Chadha ed ., *Environmental Degradation in India* [ M ] . Jammu: Vinod Publishers, 83—96
- Hietel E, Waldhardt R, Otter A, 2004 . Analysing land cover changes in relation to environmental diversity in Hesses, Germany [ J ] . *Landscape Ecology*, 19 ( 5 ) : 473—489
- Joshi PK, Gairola S, 2004 . Understanding land cover dynamics in Garhwal Himalayas using geospatial tools-a case study of Balkhila Sub-Watershed [ J ] . *Journal of the Indian Society of Remote Sensing*, 32 ( 2 ) : 199—208
- Joshi PK, Das KK, Jamwal AK *et al.*, 2004 . Analyzing land cover dynamics vis-à-vis topography in Huinyal Watershed ( Garhwal Himalayas) using geospatial tools [ J ] . *Indian Journal of Forestry*, 27 ( 1 ) : 1—10
- Joshi PK, Yang XF, Agarwal SP *et al.*, 2003 . Impact of resource utilization in lesser Himalayan watershed-landscape ecological approach for watershed development and planning [ J ] . *Asian Journal of Geoinformatics*, 3 ( 4 ) : 1—9
- Li QH, 2005 . Land use land cover change analysis in Pali Gad Sub-watershed and its impact on erosion processes, master thesis [ D ] . Kunming: Kunming Institute of Botany, Chinese Academy of Sciences
- Patton MQ, 1981 . *How to Use Qualitative Methods in Evaluation* [ M ] . New Delhi: Sage, 179, 176
- Samant SS, Dhar U, 1997 . Diversity, endemism and economic potential of wild edible plants of Indian Himalaya [ J ] . *International Journal of Sustainable Development & World Ecology*, 4: 179—191
- Schmidth-Vogt D, 1990 . *High Altitude Forests in the Jugal Himal* . Eastern-Central Nepal: Forest Types and Human Impact [ M ] . Sfuftgart: Franz Steinar Verlag, 210
- Sharma A, Prasad R, Saksena S *et al.*, 1999 . Micro-level sustainable biomass system development in Central Himalayas: Stress computation and Biomass planning [ J ] . *Sustainable Development*, 7: 132—139
- Singh SP, Singh JS, 1991 . Analytical conceptual plan to reforest Central Himalaya for sustainable development [ J ] . *Environmental Management*, 15 ( 3 ) : 369—379
- Singh SP, Singh JS, 1992 . *Forest of Himalaya . Structure, Functioning and Impact of Man* [ M ] . Nainital: Gyanodaya Prakashan, India, 294
- Singh TV, 1983 . Toursim in the Himalayan how much is not too much [ A ] . In: Singh , Kaur eds ., *Studies in Eco-Development Himalaya Mountain and Men* [ M ] . Lucknow: Pronthouse, 427—452
- Sundaram KV, 1980 . *Multilevel Planning* [ M ] . New Delhi: Vikas Publications
- Van der Veen A, Otter HS, 2001 . Land use changes in regional economic theory [ J ] . *Environmental Modeling and Assessment*, 6: 145—150
- Vasudevan P, Santosh, 1987 . The role of women in energy related activities in the mountains [ A ] . In: Vinod Kumar, Dilip Ahuja eds ., *Rural Energy Planning of the India Himalaya* [ M ] . New Delhi: Wiley Eastern Pct . Ltd
- VeldKamp A, Fresco LO, 1996 . CLUE: a conceptual model to study the conversion of land use and its effects [ J ] . *Ecological Modelling*, 85: 253—270
- Wackernager M, Rees WE, 1996 . *Out Ecological Footprints: Reducing Human Impact on Earth* [ M ] . Gabriola Island, British Columbia: New Society Publishers